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Education

University of Virginia – PhD in Mechanical and Aerospace Engineering (1995)
<u>Dissertation</u>: *A Space Marching Adaptive Remeshing Technique applied to the 3D Euler Equations for Supersonic Flow.*

Princeton University – BS in Mechanical and Aerospace Engineering (1987)
<u>Thesis</u>: *A Computational Study of the Combustion Processes in a Scramjet Engine to be used for the National Aerospace Plane.*

Research Accomplishments

I am currently employed as an Applied Mathematician at the Naval Research Laboratory. The focus of my research has been in the development of accurate and efficient computer models for predicting the behavior of the atmosphere and ocean. In order to construct these new models, I have had to develop a new continuous form of the governing equations of motion, devise new numerical methods for solving these hyperbolic nonlinear chaotic partial differential equations, and create efficient strategies for solving the discrete equations on massively parallel computers. The spatial discretization methods that I have developed are all Galerkin methods such as: spectral transform, finite/spectral element (FE/SE) , and discontinuous Galerkin (DG) methods. The time-differencing schemes that I have developed include explicit and semi-implicit methods as well as fully implicit semi-Lagrangian methods. The hybrid spectral element semi-Lagrangian, SESL, method that I developed combines space and time into a unified high-order discretization. Based on all of these ideas I have constructed a new atmospheric model called NSEAM; more information can be found at www.nrlmry.navy.mil/~giraldo/projects/nseam.html. Using Open MP, Message-Passing Interface (MPI), iterative matrix solvers (GMRES), and matrix preconditioners (block Jacobi), NSEAM has successfully surpassed the current U.S. Navy operational forecast model in efficiency. The NSEAM model which I have developed has been shown to be more accurate than any other atmospheric model currently in existence. The U.S. Navy plans to use NSEAM for its daily numerical weather prediction needs in the near future. In addition, the Alfred-Wegener Institute in Germany plans to use NSEAM for climate studies involving the Arctic region and are developing a model, based on NSEAM, for their future climate research studies. The success of the NSEAM model is due to a combination of breakthroughs in the areas of scientific computing, numerical and analytic methods for partial differential equations, and grid generation.

Professional Appointments

Applied Mathematician – Naval Research Laboratory, Monterey CA (October 1997 - Present).

University Corporation for Atmospheric Research (UCAR) Fellow – Naval Research Laboratory, Monterey CA (April 1997 - October 1997).

Office of Naval Research (ONR) Fellow – Naval Research Laboratory, Monterey CA (April 1996 - April 1997).

Adjunct Professor – Department of Applied Mathematics, Naval Postgraduate School, Monterey CA (February 1996 - April 1996).

National Research Council (NRC) Research Fellow – Department of Applied Mathematics, Naval Postgraduate School, Monterey CA (February 1995 - February 1996).

Research Grants

Naval Research Laboratory Washington DC (Research Advisory Committee) – Co-Principal Investigator on a ($475K/year) grant to develop *Conservative Discontinuous Galerkin Coastal Ocean and Transport Models* for the U.S. Navy (October 2005 - October 2007).
Naval Research Laboratory Washington DC (Research Advisory Committee) – Co-Investigator on a ($500K/year) grant to study *Hurricanes using a Spectral Element Global Atmospheric Model* (October 2005 - October 2007).
Office of Naval Research (Climate, Weather, and Ocean Directorate) – Principal Investigator on a ($200K/year) grant to explore *Advanced Numerical Methods for Numerical Weather Prediction Models* (Renewed for October 2003 - October 2006).
Office of Naval Research (Climate, Weather, and Ocean Directorate) – Principal Investigator on a ($200K/year) grant to explore *Advanced Numerical Methods for Numerical Weather Prediction Models* (October 2000 - October 2003).

Honors & Awards

NRL, Washington DC – Alan Berman Research Prize for best publication (2002)

NRL, Monterey CA – Outstanding performance awards (1998, 1999, 2000, 2001, 2002, 2003)

Journal of Computational Physics – Publication *Lagrange-Galerkin Methods on Spherical Geodesic Grids* selected for the cover of the issue Vol. 136, Number 1, September 1997.

Teaching Experience

Lecturer in the Department of Applied Mathematics, Naval Postgraduate School, Monterey CA (Spring 2004; course title: Introduction to Vector Analysis).

Lecturer in the Department of Meteorology, Naval Postgraduate School, Monterey CA (September 1998 - Present; yearly one week lectures to Prof. R.T. Williams class on Advanced Numerical Weather Prediction.

Adjunct Professor in the Department of Applied Mathematics, Naval Postgraduate School, Monterey CA (February 1996 - April 1996; course titles: Single and Multi-variable Calculus).

Lecturer/Teaching Assistant in the Department of Mechanical and Aerospace Engineering, University of Virginia, Charlottesville VA (September 1989 - May 1993; course titles: Finite Element Methods and Introduction to Fluid Dynamics).

Instructor in the Department of Mechanical and Aerospace Engineering, Rutgers University, New Brunswick NJ (September 1988 - May 1989; course title: Introduction to Fluid Dynamics).

Professional Memberships

Sigma Xi – Full member (since 1997).

Society for Industrial and Applied Mathematics – Society Member and Member of Computational Science working group (since 1999).

Publications

Journal Articles

1. *A Prolate Element Method for Solving Partial Differential Equations in Spherical Geometry: Generalization of Legendre-based Spectral Elements*, 1st Author with J.P. Boyd – SIAM Journal on Scientific Computing, in preparation (2004).

2. *A Nodal Triangle-based Spectral Element Method for the Shallow Water Equations on the Sphere: Inexact Integration and Diagonal Mass Matrices*, 1st Author with T. Warburton – Journal of Computational Physics, in preparation (2004).

3. *A Nodal Triangle-based Spectral Element Method for the Shallow Water Equations on the Sphere*, 1st Author with T. Warburton – Journal of Computational Physics, submitted (2004).

4. *Semi-implicit Time-Integrators for a Scalable Spectral Element Atmospheric Model*, Single Author – Quarterly Journal of the Royal Meteorological Society, in review (2004).

5. *A Scalable Spectral Element Eulerian Atmospheric Model (SEE-AM) for NWP: Dynamical Core Tests*, 1st Author with T. Rosmond – Monthly Weather Review, Vol.132, 133-153 (2004).

6. *A Spectral Element Semi-Lagrangian (SESL) Method for the Spherical Shallow Water Equations*, 1st Author with J.B. Perot and P.F. Fischer – Journal of Computational Physics, Vol. 190, 623-650 (2003).

7. *Strong and Weak Lagrange-Galerkin Spectral Element Methods for the Shallow Water Equations*, Single Author – Computers and Mathematics with Applications, Vol. 45, 97-121 (2003).

8. *Nodal High-Order Discontinuous Galerkin Methods for the Spherical Shallow Water Equations*, 1st Author with J.S. Hesthaven and T. Warburton – Journal of Computational Physics, Vol. 181, 499-525 (2002).

9. *Analysis of an Exact Fractional-Step Method*, 2nd Author with W. Chang and J.B. Perot – Journal of Computational Physics, Vol. 180, 183-1995 (2002).

10. *A Spectral Element Shallow Water Model on Spherical Geodesic Grids*, Single Author – International Journal for Numerical Methods in Fluids, Vol. 35, 869-901 (2001).

11. *The Lagrange-Galerkin Method for the 2D Shallow Water Equations on Adaptive Grids*, Single Author – International Journal for Numerical Methods in Fluids, Vol 33, 789-832 (2000).

12. *Lagrange-Galerkin Methods on Spherical Geodesic Grids: The Shallow Water Equations*, Single Author – Journal of Computational Physics, Vol 160, pp 336-368 (2000).

13. *Trajectory Calculations for Spherical Geodesic Grids in Cartesian Space*, Single Author – Monthly Weather Review, Vol 127, pp 1651-1662 (1999).

14. *Stability Analysis for Eulerian and Semi-Lagrangian Finite Element Formulation of the Advection-Diffusion Equation*, 1st Author with B. Neta – Computers & Mathematics with Applications, Vol 38, pp 97-112 (1999).

15. *The Lagrange-Galerkin Spectral Element Method on Unstructured Quadrilateral Grids*, Single Author – Journal of Computational Physics, Vol 147, pp 114-146 (1998).

16. *Lagrange-Galerkin Methods on Spherical Geodesic Grids*, Single Author – Journal of Computational Physics, Vol 136, pp 197-213 (1997).

17. *Analysis of the Turkel-Zwas scheme for the Two-Dimensional Shallow Water Equations in Spherical Coordinates*, 2nd Author with B. Neta and I.M. Navon – Journal of Computational Physics, Vol 133, pp 102-122 (1997).

Chapters in Books

1. *Examples of the Spectral Element Semi-Lagrangian (SESL) Method* developed by F.X. Giraldo – in Spectral/hp Element Methods in CFD (2nd Edition), G.E. Karniadakis and S.J. Sherwin, Oxford University Press (2005).

2. *A Comparison of a Family of Eulerian and Semi-Lagrangian Finite Element Methods for the Advection-Diffusion Equation: Numerical Results* 1st Author with B. Neta – pp. 217-229 in Computer Modeling of Seas and Coastal Regions III, J.R. Acinas and C.A. Brebbia, Southampton (1997).

3. *Examples of Mesh2D package* developed by F.X. Giraldo – in Chapters 9 and 10 of The Finite Element Method for Engineers (3rd Edition), Huebner and Thornton, Houghton (1995).

Conference Proceedings

1. *A Spectral Element Eulerian-Lagrangian Atmospheric Model*, Single Author – Workshop on Current Development in Shallow Water Models on the Sphere, Garching Germany (March 2003).

2. *Characteristic-based Spectral Element Methods for the Shallow Water Equations on the Sphere*, Single Author – European Congress on Computational Methods in Applied Science and Engineering, Barcelona Spain (September 2000).

3. *Two Lagrange-Galerkin Spectral Element Methods for the Shallow Water Equations*, Single Author – 20th Iberian Latin-American Congress on Computational Methods in Engineering, São Paulo Brazil (November 1999).

4. *A Spectral Element Semi-Lagrangian Method for the 2D Shallow Water Equations on Unstructured Grids*, Single Author – 4th World Congress on Computational Mechanics, Buenos Aires Argentina (June 1998).

5. *Efficiency and Accuracy of Lagrange-Galerkin Methods on Adaptive Unstructured Grids*, Single Author – Mathematical Modeling and Scientific Computing, Washington DC (November 1997).

6. *A Finite Volume High Resolution 2D Euler Solver with Adaptive Grid Generation on High Performance Computers*, Single Author – Finite Elements in Fluids, Venice Italy (October 1995).

7. *A Parallel Domain Decomposition Method for a semi-Lagrangian Finite Element Air Pollution Transport Model*, Single Author – International Symposium on Parallel and Distributed Supercomputing, Fukuoka Japan (September 1995).

Conference Abstracts

1. *Recent Advances in the NRL Spectral Element Atmospheric Model (NSEAM)*, Single Author –

The 2004 Workshop on the Solution of Partial Differential Equations on the Sphere, Yokohama Japan (July 2004).

2. *Minisymposium Organizer on Local High-Order Methods for Geophysical Fluid Dynamics*, Single Author – 6th International Conference on Spectral and High-Order Methods (ICOSAHOM), Providence RI (June 2004).

3. *A Semi-Implicit Spectral Element Global Atmospheric Model: Performance on Distributed-Memory Computers*, Single Author – American Geophysical Union Fall Meeting, San Francisco CA (December 2003).

4. *Minisymposium Organizer on High-Order and Conservative Semi-Lagrangian Methods*, with J. Behrens – SIAM Conference on Computational Science and Engineering, San Diego CA (February 2003).

5. *A Scalable Spectral Element Eulerian Atmospheric Model: Dynamical Core Tests*, Single Author – The 2002 Workshop on the Solution of Partial Differential Equations on the Sphere, Toronto Canada (June 2002).

6. *Minisymposium Organizer on Adaptive and Mutliscale Methods for Ocean and Atmosphere Modeling*, with J. Behrens – SIAM Conference on Mathematical and Computational Issues in the Geosciences, Boulder CO (June 2001).

7. *A Spectral Element Dynamical Core in Cartesian Coordinates*, Single Author – The 2001 Workshop on the Solution of Partial Differential Equations on the Sphere, Montreal Canada (May 2001).

8. *Lagrange-Galerkin and Spectral Element Methods on Spherical Geodesic Grids: The Shallow Water Equations*, Single Author – The 1999 Workshop on the Solution of Partial Differential Equations on the Sphere, San Francisco CA (December 1999).

9. *Lagrange-Galerkin and Spectral Element Methods on Spherical Geodesic Grids*, Single Author – The 1998 Workshop on the Solution of Partial Differential Equations on the Sphere, Gatlinburg TN (April 1998).

Invited Talks

1. *Element-based Galerkin Methods for the NSEAM Global Atmospheric Model* – Alfred-Wegener Institute, Potsdam Germany (March 2004, invited by Prof. Klaus Dethloff).

2. *Local High-Order Nodal Methods for Atmospheric Modeling* – Max-Planck Institute, Hamburg Germany (March 2003, invited by Prof. Erich Roeckner).

3. *Spectral Element Semi-Lagrangian Atmospheric Models (SESLAM) on Distributed-memory Computers* – Scientific Computing Division, National Center for Atmospheric Research, Boulder CO (August 2002, invited by Dr. Steve Thomas).

4. *Characteristic-based Spectral Element Methods for the Shallow Water Equations on the Sphere* – Division of Applied Mathematics, Brown University, Providence RI (April 2000, invited by Prof. George Karniadakis).

5. *Lagrange-Galerkin Methods on Spherical Geodesic Grids: The Shallow Water Equations* – Department of Atmospheric Sciences, Colorado State University, Fort Collins CO (September 1999, invited by Prof. David Randall).

6. *A Weak Lagrange-Galerkin Shallow Water Model on the Sphere* – X-HM, Los Alamos National Laboratory, Los Alamos, NM (December 1998, invited by Dr. Mark Taylor).

7. *Lagrange-Galerkin Methods on Spherical Geodesic Grids* – Institute for Marine and Coastal Sciences, Rutgers University, New Brunswick NJ (April 1997, invited by Prof. Dale Haidvogel).

8. *Eulerian and Semi-Lagrangian Finite Element Models for Advection Dominated Flows* – Department of Oceanography, Florida State University, Tallahasee FL (March 1996, invited by Prof. Jim O'brien).

9. *A Space Marching Adaptive Remeshing Technique (SMART) applied to the 3D Euler Equations for Supersonic Flow* – Laboratory for Computational Physics, Naval Research Laboratory, Washington DC (August 1994, invited by Dr. Jay Boris).

Reviewer for

Air Force Office of Scientific Research

Cambridge University Press

Computers and Fluids

Dynamics of Atmospheres and Oceans

IEEE Computing in Science and Engineering

International Journal for Numerical Methods in Fluids

Journal of Computational Physics

Journal of Scientific Computing

Monthly Weather Review

National Science Foundation

SIAM Journal on Scientific Computing

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